

# Introduction to the U.S. Department of Energy's Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project

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# Outline

- Project Overview
  - Objectives & key targets
  - Teams & plans
- Data Analysis
  - Data collection
  - Sample data analyses
- Conclusions

No confidential or proprietary data is contained in this presentation

# Project Objectives and Targets

- Objectives
  - Validate “System” Solutions for H<sub>2</sub> Transportation
  - Identify Status of Technology
  - Re-Focus Research and Development
  - Support Industry Commercialization Decision by 2015



Hydrogen and gasoline station, WA DC

## Key Targets

Performance Measure	2009*	2015**
Fuel Cell Stack Durability	2000 hours	5000 hours
Vehicle Range	250+ miles	300+ miles
Hydrogen Cost at Station	\$3.00/gge	\$1.50/gge

\* To verify progress toward 2015 targets

\*\* Subsequent projects to validate 2015 target

# Successful Teams Announced



(1) Fuel cells supplied by Ballard

# Team Overview – ChevronTexaco

**ChevronTexaco**

**HYUNDAI**

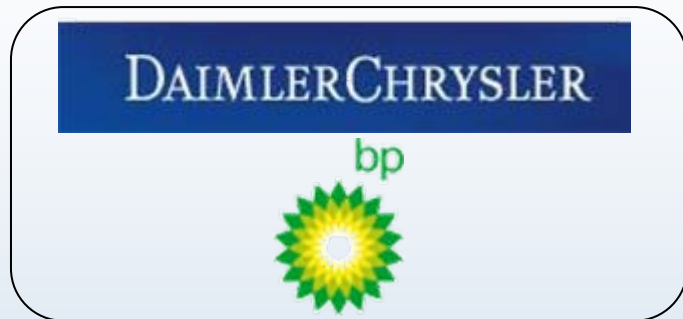
**UTC Fuel Cells**  
A United Technologies Company

- 32 Fuel Cell Vehicles
  - SUVs
  - 2 Fuel Cell Generations
- Up to 6 Fueling Stations
- 2 regions

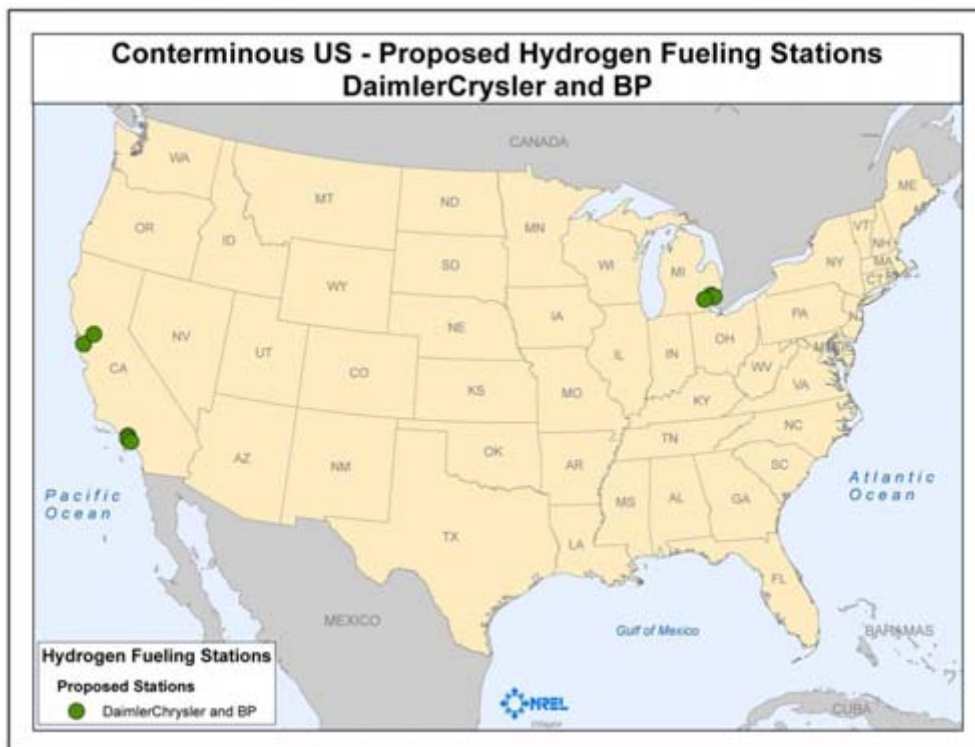
**Conterminous US - Proposed Hydrogen Fueling Stations  
ChevronTexaco and Hyundai**



# Team Overview – DaimlerChrysler



- 36 Fuel Cell Vehicles
  - F-Cell Vehicles & Sprinter Vans (Gen 1)
  - 2 Fuel Cell Generations
- Up to 8 Fueling Stations
- 3 regions



# Team Overview – Ford



Conterminous US - Proposed & Existing Hydrogen Fueling Stations  
Ford and BP



- 26 Fuel Cell Vehicles
  - Ford Focus Vehicles (Gen 1)
  - 2 Fuel Cell Generations
- Up to 7 Fueling Stations
- 3 regions



# Team Overview – GM



- 40 Fuel Cell Vehicles
  - Opel Zafira Vehicles (Gen 1)
  - 2 Fuel Cell Generations
- Up to 7 Fueling Stations
- 4 regions

Conterminous US - Proposed & Existing Hydrogen Fueling Stations  
General Motors and Shell



# Refueling Stations from All Four Teams Begin to Create Regional Networks



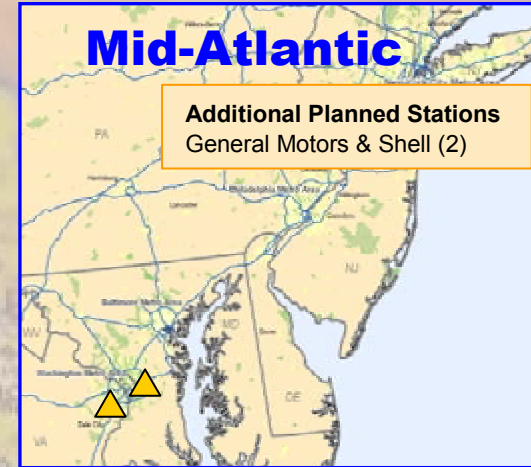
## Northern California

**Additional Planned Stations**  
 Ford & BP (up to 4)  
 DaimlerChrysler & BP (up to 3)  
 General Motors & Shell (1)  
 ChevronTexaco & Hyundai (up to 2)



## SE Michigan

**Additional Planned Stations**  
 DaimlerChrysler & BP (up to 2)  
 General Motors & Shell (1)  
 ChevronTexaco (up to 2)



## Mid-Atlantic






**Additional Planned Stations**  
 General Motors & Shell (2)



## Southern California

**Additional Planned Stations**  
 DaimlerChrysler & BP (2)  
 General Motors & Shell (1)  
 ChevronTexaco (2)

**Online Stations**

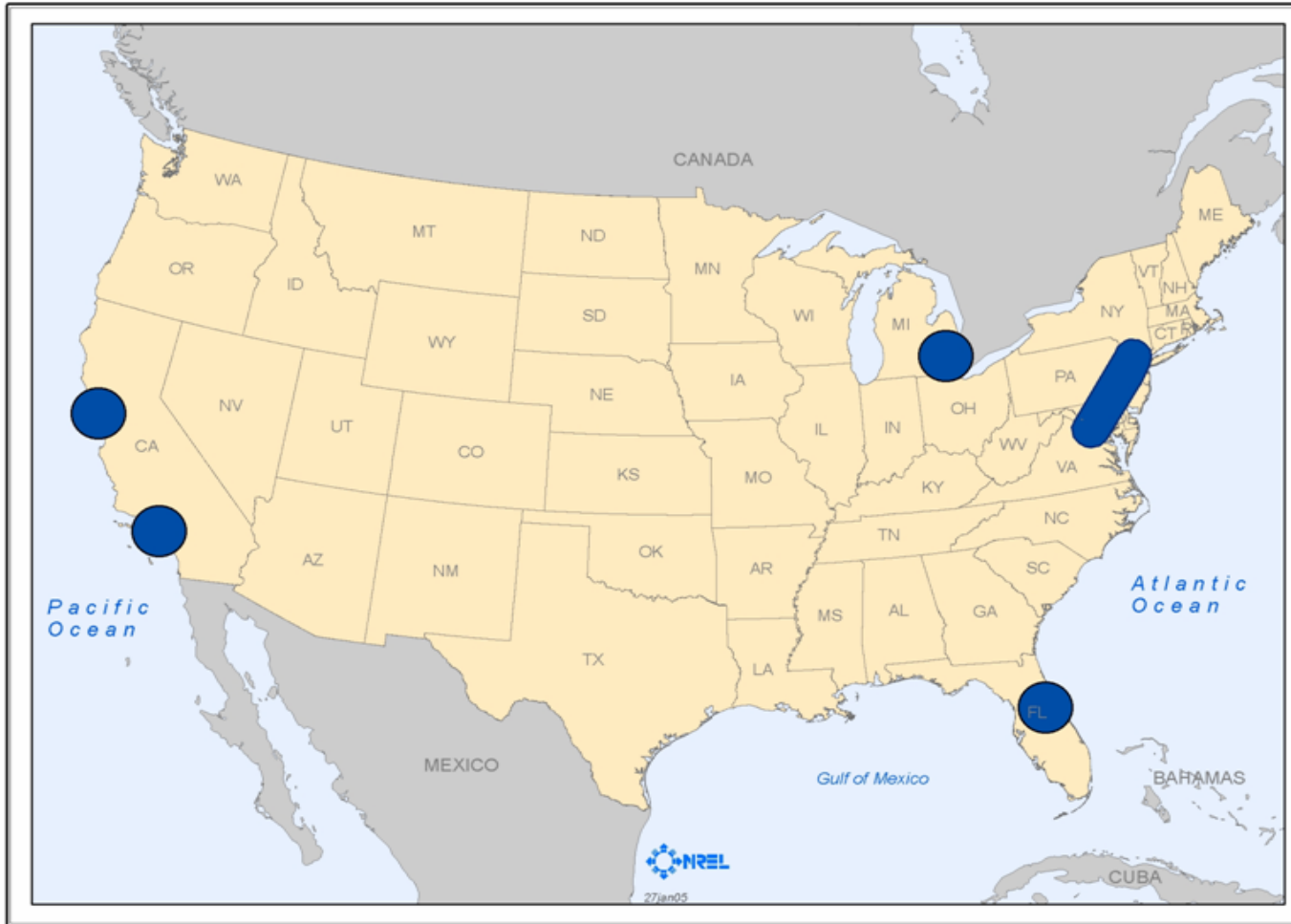
-  Ford & BP
-  ChevronTexaco
-  DaimlerChrysler & BP
-  General Motors & Shell
-  Other Companies



## Florida

**Additional Planned Stations**  
 Ford & BP (1)

# Data Collection: Diverse Geography Addresses Four Key U.S. Climates



Cold, Moderate, Hot/Humid, Hot/Arid Climates

# Teams Will Field Four Main\* Types of Vehicles



\*DaimlerChrysler will also have FCV Sprinter vans



# Sample Hydrogen Refueling Infrastructure



DTE/BP Power Park,  
Southfield, MI



LAX refueling station



Hydrogen and gasoline station, WA DC

Photo:Shell Hydrogen



Chino, CA

Photo: H2CarsBiz

# Data Collection: Overview

Key Vehicle Data	Key Infrastructure Data
Stack Durability	Conversion Method
Fuel Economy (Dyno & On-Road) and Vehicle Range	Production Emissions
Fuel Cell System Efficiency	Maintenance, Safety Events
Maintenance, Safety Events	Hydrogen Purity/Impurities
Top Speed, Accel., Grade	Refueling Events, Rates
Max Pwr & Time at 40C	H <sub>2</sub> Production Cost
Freeze Start Ability (Time, Energy)	Conversion, Compression, Storage and Dispensing Efficiency
Continuous Voltage and Current (or Power) from Fuel Cell Stack, Motor/Generator, Battery & Key Auxiliaries: (Dyno & On-Road)	

# Data Collection & Analysis Process

## Hydrogen Secure Data Center (HSDC)

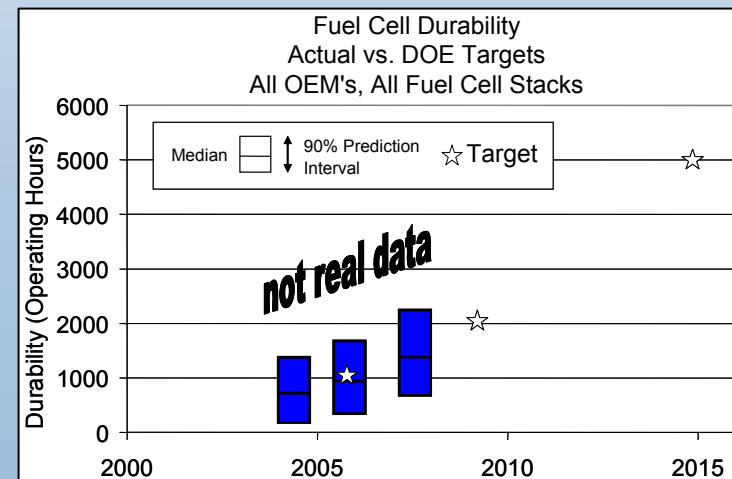
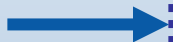
- @ NREL: Strictly Controlled Access
- Detailed Analyses, Data Products, Internal Reports
- HSDC ADVISOR



## Composite Data Products

- Pre-Agreed Upon Aggregate Data Products
- No Confidential Information

Raw Data, Reports



# Sample Composite Data Examples to Be Presented to Public Within Next 5 Years

## A. Critical Program Metrics:

1. Fuel Cell Durability, Actual vs. DOE Targets, All OEM's
2. Vehicle Ranges, Actual vs. DOE Targets, All OEM's
3. H2 Production Cost, Actuals/Projections vs. DOE Targets

## B. Composite Performance Tracking:

### Vehicles

4. Reliability (FC System & Powertrain, MTBF)
5. Start Times vs. DOE Target
6. Fuel Economy: Dyno, On-Road
7. Normalized Vehicle Fuel Economy
8. Fuel Cell System Efficiency
9. Safety Incidents - Vehicle Operation
10. Weight % Hydrogen
11. Mass of Hydrogen per Liter
12. Vehicle Hydrogen Tank Cycle Life

### Hydrogen Infrastructure

13. H2 Production Efficiency vs. Process
14. Combined Heat and Power (CHP) Efficiencies
15. H2 Production Cost vs. Process
16. H2 Purity vs. Production Process
17. Hydrogen Impurities - Range for Production Process A
18. Histogram: Refueling Rate
19. Average Maintenance Hours - Scheduled and Unscheduled

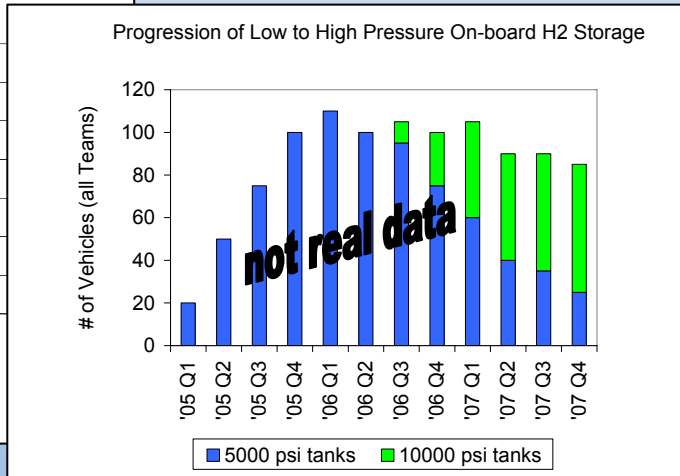
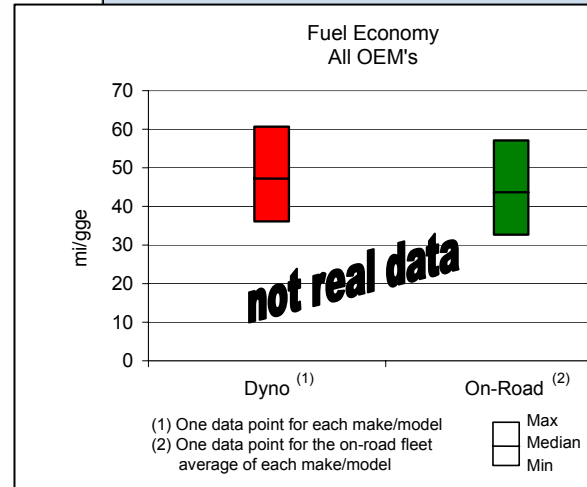
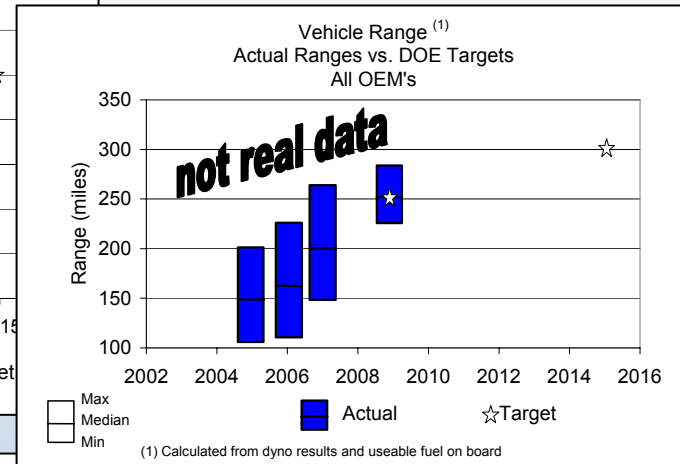
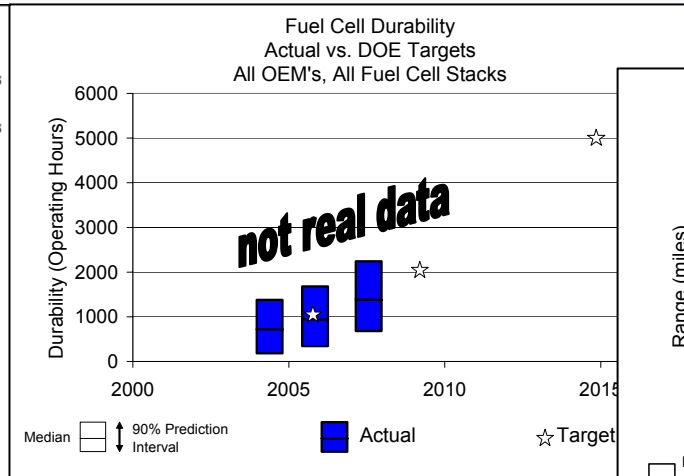
## C. High Level Program Progress:

### Vehicles

20. Range of Actual Ambient Temperatures During Vehicle Operation - All Vehicle Teams
21. Histogram: # Vehicles vs. Operating Hours to Date
22. Histogram: # Vehicles vs. Miles Traveled to Date
23. Cumulative Vehicle Miles Traveled - All Teams
24. Progression of Low to High Pressure On-board H2 Storage

### Hydrogen Infrastructure

25. Cumulative Hydrogen Production - All Teams





# Handling Data Security at NREL

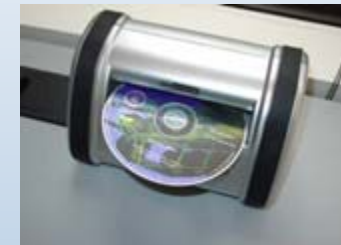
- Protects all raw data and our analysis results
- Only things that leave room:
  - composite data results
  - trend feedback into R&D



Server, workstation, tape backup and UPS



Two computer workstations



CD/DVD shredder



paper shredder



Motion sensors



Audible alarm



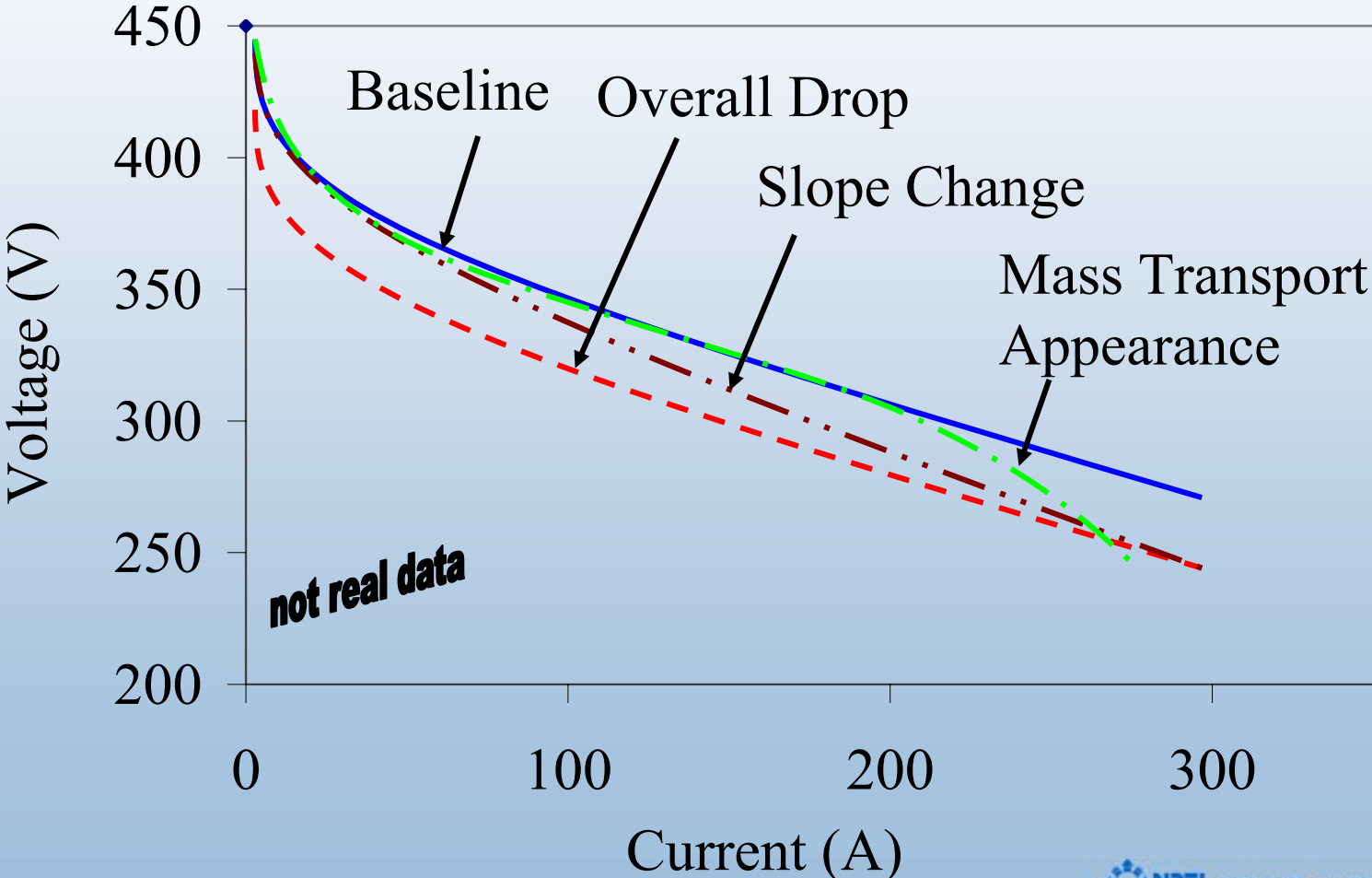
PIN reader badge scanner



1350 lb. safe for backups

# Analysis Example: FC Stack Degradation

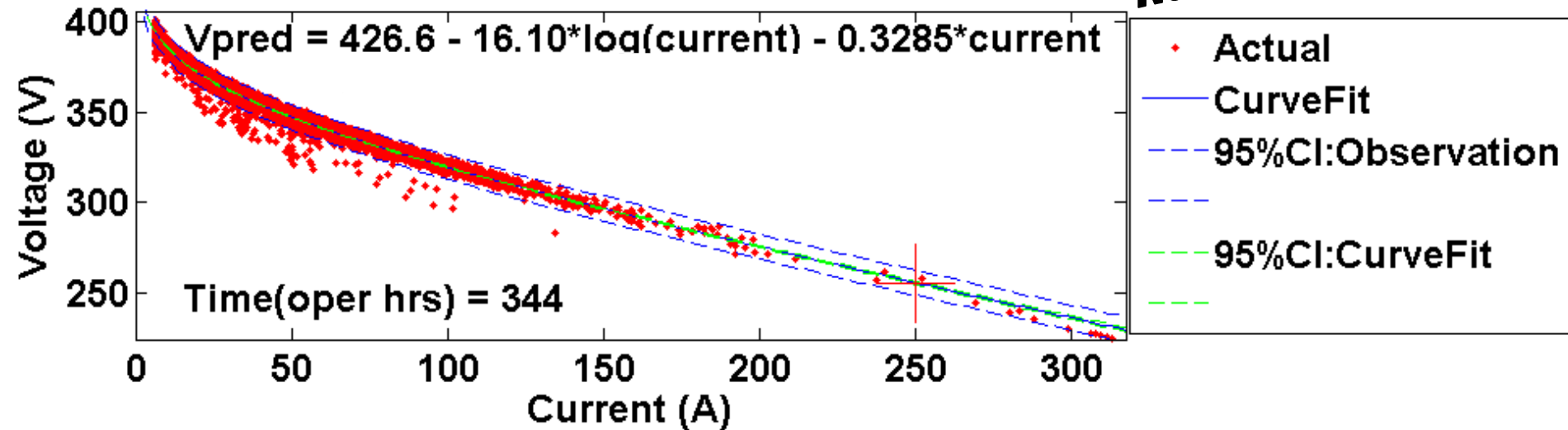
Various Fuel Cell Polarization Curve Changes



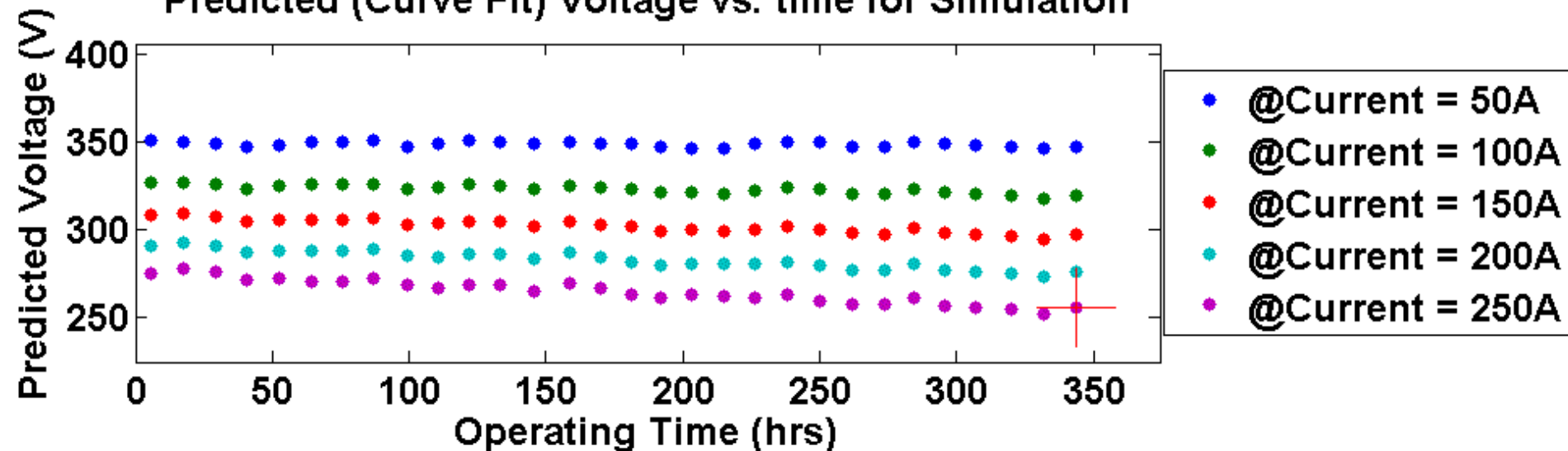
# Analysis Example: Stack Degradation

Fuel Cell Stack VI Animation for Simulation

**Not Real Data**

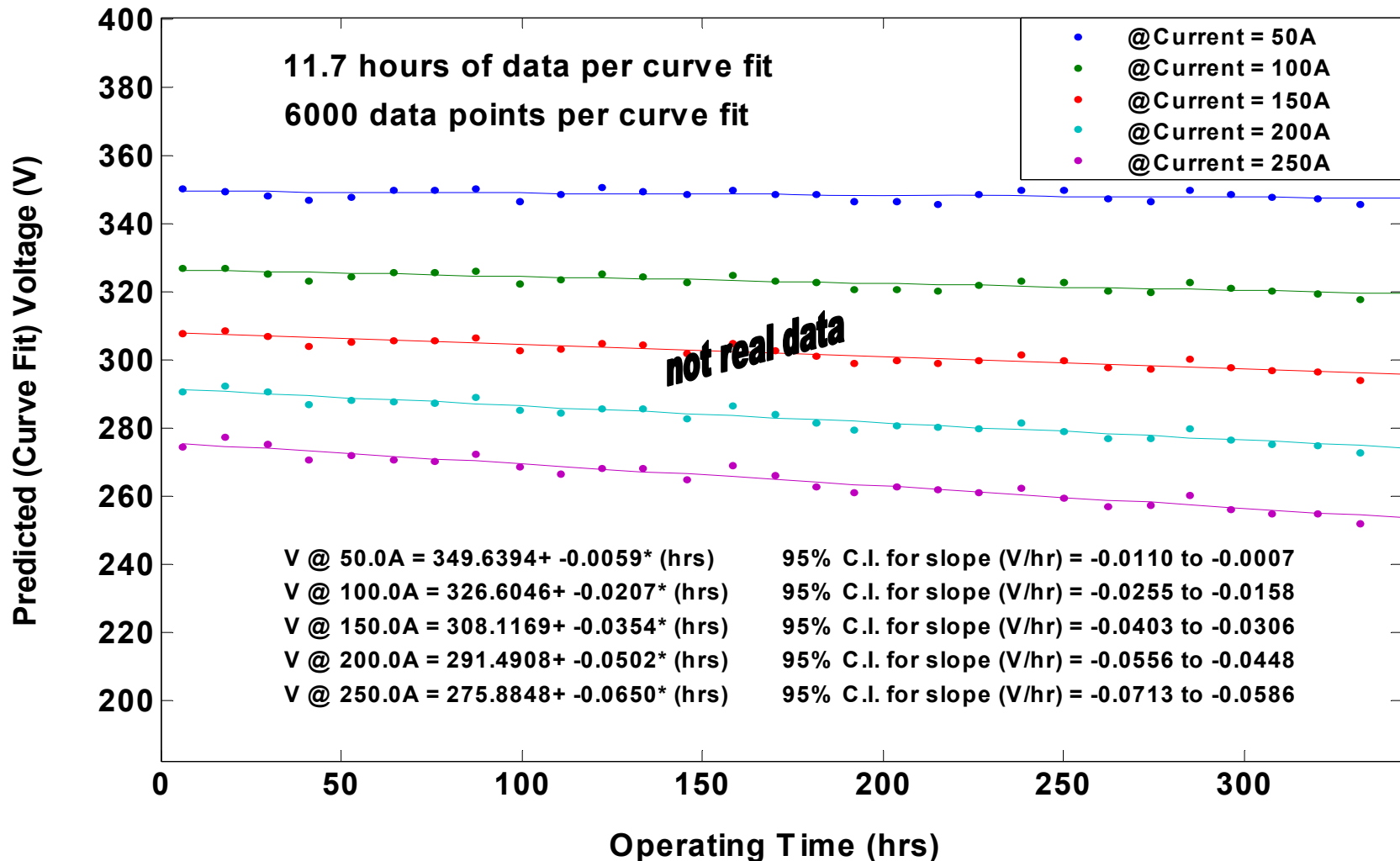


Predicted (Curve Fit) Voltage vs. time for Simulation

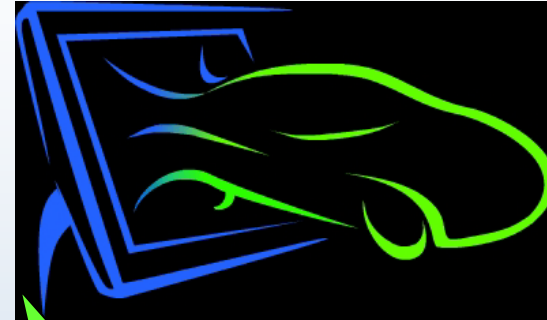
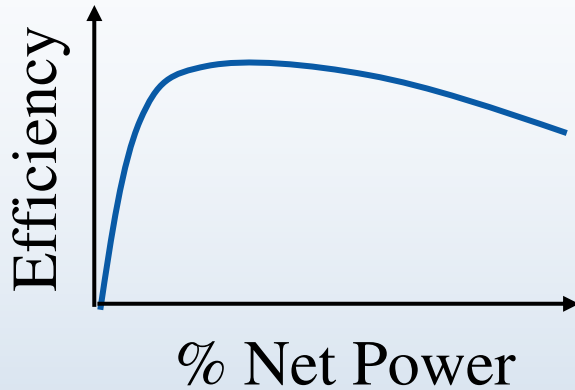


# Analysis Example: Stack Degradation

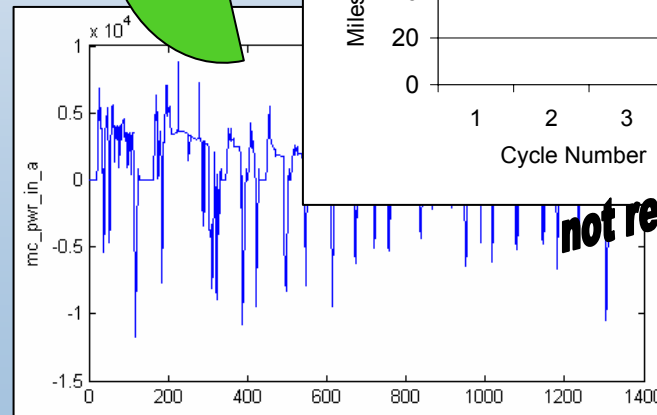
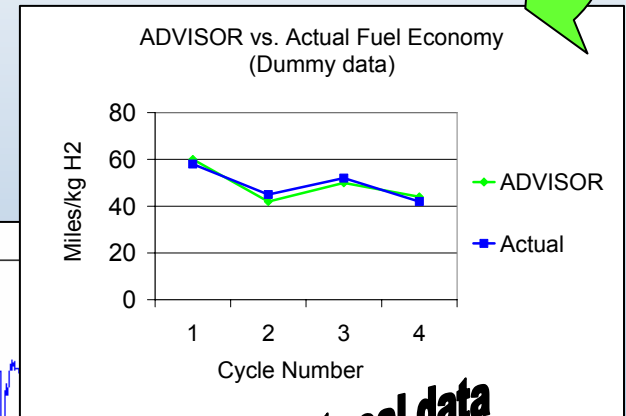
Predicted (Curve Fit) Voltage vs. time for Simulation



# HSDC ADVISOR Will Assist in Trade-Off Studies and Refocusing R&D



Vehicle, Power Plant Parameter Summary	
<i>Include parameters for each vehicle and power plant</i>	
Report Date	<i>insert report date</i>
Automaker	<i>insert automaker</i>
Parameter	Units
veh_CD <sup>(1)</sup>	dimensionless
veh_FA <sup>(1)</sup>	m <sup>2</sup>
Vehicle Mass <sup>(1)</sup>	kg
veh_front_wt_frac <sup>(1)</sup>	dimensionless
veh_cg_height <sup>(1)</sup>	m
veh_wheelbase <sup>(1)</sup>	m
Fuel Cell System	
c. Power Rating (net)	kW
Propulsion Battery or Capacitor	
c. Maximum Rated Ampere-Hour Capacity	Ampere*hrs
Electric Propulsion Motor	
b. Peak Power Rating	kW



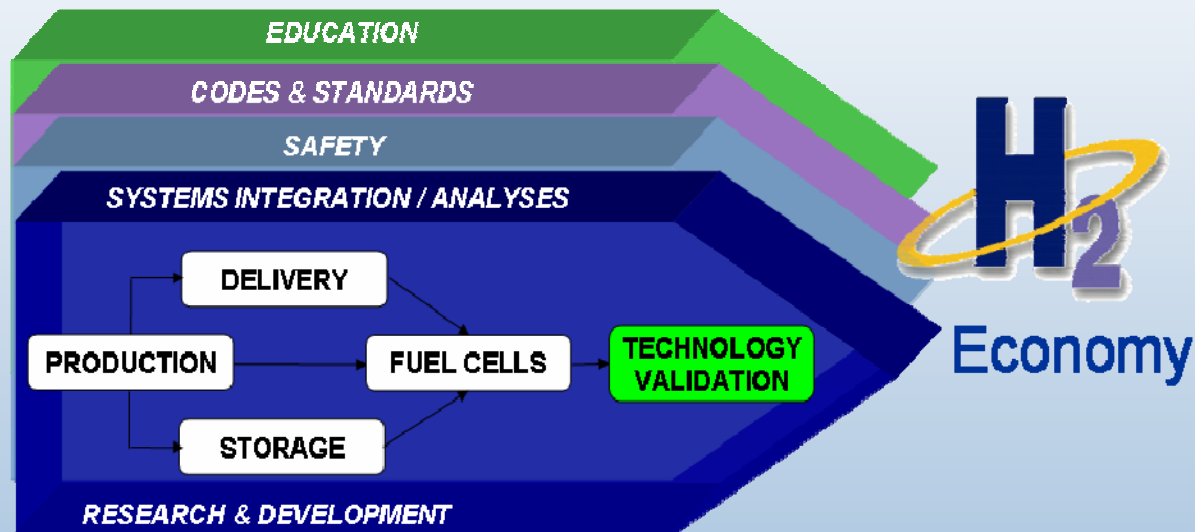
# Recent Activities – Opening of ChevronTexaco Station in China



# Conclusions

- A data collection and management system has been implemented to provide critical information on:
  - Fuel cell lifetime, voltage degradation, and system efficiency
  - Vehicle range, fuel economy, and progress of H2 storage systems
  - Hydrogen production efficiencies and H2 purity
  - Refueling infrastructure performance
  - Other data to mark progress toward DOE technical targets
- Data will:
  - Help to identify status of technology
  - Re-Focus Research and Development
  - Support Commercialization Decision by 2015
- 25 key composite data products will be available to public
  - Show progress toward DOE/industry targets
- Data collection/reporting by partners has begun
- DOE coordination internationally through interagency programs and with state initiatives

# Questions?



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